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Sleep habits in adolescents of Saudi Arabia; distinct patterns and extreme sleep schedules

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ABSTRACT

Background and Study Objectives: There is a need for comprehensive studies on adolescents' sleep habits in the Middle Eastern region. The aim of this study was to investigate the sleep–wake patterns, prevalence of excessive daytime sleepiness (EDS), and disturbed sleep among adolescents in Saudi Arabia and to identify the associated factors.

Methods: The study was a cross-sectional survey done on a random sample of 1035 high school students, ages 14–23 years, in Jeddah, Saudi Arabia. The response rate was 91%. Students filled a self-reported questionnaire that included sleep–wake questions, Pittsburgh Sleep Quality Index, Epworth Sleepiness Scale, Perceived Stress Scale, academic performance, and personal data.

Results: Students slept an average of 7.0 hours on school nights, with an average delay of 2.8 and 6.0 hours in weekend sleep and rise times, respectively. Around 1 in 10 students stayed up all night and slept after returning from school (exhibiting a reversed sleep cycle) on weeknights. This pattern was more prevalent among boys and students with lower grade point averages. The prevalence of sleep disturbance was 65%, and EDS was found in 37% of the students. Predictors of EDS were school type, stress, napping and caffeine use, while gender was a predictor of disturbed sleep.

Conclusions: Adolescents in Saudi Arabia showed a high percentage of poor sleep quality. Compared with adolescents from other countries, they had a larger delay in weekend sleep and rise times. An alarming reversed sleep cycle on weekdays is present and highlights the need for further assessment.

1. Introduction

Sleep problems are growing internationally among the youth, as evidenced by studies from different parts of the world [1–3]. Research investigating the prevalence, causes, and consequences of adolescents' sleep problems has mainly focused on three aspects of sleep: sleep duration, sleep quality, and daytime sleepiness [4–6]. Adolescent sleeping patterns are affected by social, psychological, physiological, and environmental factors [4]. Adolescents experience a biological sleep phase delay [7], in addition to rigid early school start times [8,9], elevated academic and social demands, and increased exposure to electronic media [10], all of which contribute to shortened and disturbed sleep [4]. The excessive use of electronic media has been associated with delayed bedtimes and shorter sleep [11], and the late night use of technology (after 9 pm) has been associated with shorter sleep [12].

The consequences of adolescent sleep problems are well documented in the literature. However, there is no sufficient high-level evidence supporting the recommendations for optimal hours of sleep in children and teenagers [13]. Nonetheless, shorter hours of sleep in adolescents, mainly below 8–9 hours, have been linked to a variety of negative outcomes, including obesity [14], impaired insulin resistance [15], poor mental health [16], and substance use/abuse [17], as well as poor academic performance [1,18]. Disturbed sleep has also been associated with an increase in the expression of markers of cardiovascular risk [19], high frequency of depression [20] and anxiety [21], poor mental health [16], poor school performance [6], and an increase in risky behavior [22]. In addition, excessive daytime sleepiness has been linked to poor school achievement [6] and risky behavior in adolescents [23].

The first aim of this study was to investigate the sleep–wake patterns and prevalence of poor sleep quality and excessive daytime sleepiness among adolescents in Saudi Arabia. Studies on the

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prevalence of sleep problems have shown that these problems are common among adolescents. Sleep surveys have consistently shown that adolescents get insufficient sleep and have delayed sleep–wake patterns. A meta-analysis of data from 41 countries highlighted the global trends in adolescent sleep patterns and confirmed that a worldwide delayed sleep–wake behavior pattern exists [5]. Adolescents reported later bedtimes (due to developmental delays in sleep patterns), thereby leading to shorter school night sleep time, which was compensated by longer weekend sleep time. Disturbed sleep is also common; a study on 95,680 Japanese junior and high school students found that 42% rated their sleep as being "poor" [24]. Not surprisingly, daytime sleepiness, which may reflect insufficient and poor sleep, is also common among adolescents, with the percentage of adolescents with excessive sleepiness being reported to be high in many countries [1,25–27]. Adolescents in the Middle East exhibit the same global trends in sleep problems. Studies in Palestine, Israel, and Iran indicated that the school night sleep duration was 6.4, < 7.5, and 7.7 hours, respectively [10,28,29]. A study on Kuwaiti secondary school students found high rates of insomnia, with approximately one-third of the students complaining of early morning awakening [30].

Sleep can be viewed as occurring in the context of both intrinsic (psychological, biological, maturational) and extrinsic (environmental and cultural) factors [31]. The second aim of the study was to identify factors associated with insufficient sleep, poor sleep quality, and excessive daytime sleepiness. Such factors identified in previous studies on adolescents include age [5], gender [28], stress [1], and caffeine consumption [32]. Identifying such associations can facilitate the understanding of the factors regulating sleep–wake patterns in adolescents [31], and can help generate hypothesis for future studies. Moreover, identifying factors associated with poor sleep will allow healthcare workers, school counselors, teachers and parents identify adolescents at risk, and can inform policy makers investing in educational programs for adolescents.

Compared with Western societies, Saudi Arabia in particular, and Arab societies in general, have a culture associated with a lifestyle that does not promote sufficient hours of sleep each night. Studies assessing sleep habits in a sample of 1012 elementary school children from Saudi Arabia reported that around 40% of children nap during the daytime [33], and that the mean weekday bedtime was 21:20 (±01:48) in this young age group [34]. Moreover, in his report "Sleep medicine in Saudi Arabia: Current problems and future challenges," Bahammam addressed the fact that the majority of the general public are unaware of the health risks and negative consequences associated with sleep deprivation and disturbances of biological rhythms [35]. The physiological delay in adolescents biological clock, coupled with early school start times in Saudi Arabia (between 7:00 and 7:30 am for both private and governmental high schools and an end time at around 01:30 pm for governmental schools and between 2:00 and 3:00 pm for private schools), in addition to documented napping and delayed bedtimes among elementary school students, suggests adolescents might be at a high risk of sleep deprivation, disturbed sleep patterns, and their potential negative consequences.

Sleep behavior studies in adolescents from Saudi Arabia are limited to two studies by Al-Hazzaa et al. that evaluated the relationship between sleep hours and obesity and between sleep hours and lifestyle factors in adolescents in Saudi Arabia [36,37]. In both studies, the same survey was used and the average total hours of sleep among adolescents in Saudi Arabia was documented; however, no further information on sleep variables was collected. Thus, in this exploratory study, we aimed to: (1) investigate the sleep–wake patterns and prevalence of poor sleep quality and excessive daytime sleepiness among adolescents in Saudi Arabia; and (2) to identify factors associated with insufficient sleep, poor sleep quality, and excessive daytime sleepiness. This study is the first comprehensive study that investigates adolescents' sleep habits in Saudi Arabia.

2. Methods

2.1. Sampling procedure

This cross-sectional study was conducted in Saudi Arabia's second largest city, Jeddah. The sample size needed for ±5% precision with a power level of 85% was determined to be 800. The sample size was increased to 1035 to account for non-responders. A multistage random sample was used to select the sample population from students enrolled in high schools in Jeddah. First, a stratified random sample of schools was selected. Using Jeddah schools' list, we stratified the schools according to the funding source (private or governmental) and geographic location (north, central, southeast, and southwest). In Saudi Arabia, schools are generally segregated by gender. One school was randomly selected from each stratum, thereby giving a total of 8 girls' schools and 7 boys' schools (a north male public school was not included because the school administration could not be reached). Second, in each selected school, one classroom was randomly selected from each grade, i.e., 10th, 11th, and 12th. All students in the selected classrooms were included. The Ministry of Education does not impose age restrictions for completing high school in Saudi Arabia, and no exclusions based on age were made. Nine hundred and forty seven students returned their questionnaires, thereby giving a response rate of approximately 91%. Because of the uniform protocol for survey approvals from the Ministry of Education and the absence of need for parental consent in all schools, response rates were high and did not fall below 90% across the different school funding sources (private and governmental) and grade levels, or for both genders.

2.2. Questionnaire

2.2.1. Predictors and outcome variables collected

The self-administered questionnaire collected data on the following: (1) sleep–wake patterns and sleep disturbance, using the Pittsburgh Sleep Quality Index (PSQI); (2) excessive daytime sleepiness (EDS), using the Epworth Sleepiness Scale (ESS); (3) demographic and lifestyle factors, including self-reported school performance, daily caffeine intake, and napping habits; (4) psychological distress using the Perceived Stress Scale (PSS).

The PSQI is a standardized, reliable, and valid scale developed by Buysse et al. to differentiate poor from good sleepers and evaluate the sleep quality in the past month [38]. The PSQI includes 19 self-rated questions that were included in our questionnaire. They are generally used in the adult population but easily understood by high school students. The scale begins with four questions asking about the usual sleep and wake-up time, sleep latency, and sleep duration. Fifteen multiple-choice questions follow, which inquire about sleep disturbance frequency and subjective quality of sleep. Students have to indicate how frequently they had difficulty falling asleep, insomnia, waking up during the night or too early in the morning, use of hypnotic medications, etc. For each component, they had to respond by choosing one of the following categories: not during the past month, less than once a week, once or twice a week, or three or more times a week.

Two questions about weekend sleep and rise times were added, but they were not included in the PSQI calculations, and hence, the final score was not affected. From these questions, the sleep–wake patterns, including school night sleep time and rise time, weekend sleep time and rise time, and sleep latency were measured. A global PSQI score was calculated for each student by using the PSQI scoring database. A global score ranges from 0 to 21, with higher scores indicating higher levels of sleep disturbance, and a score of >5 was used

to indicate significant sleep disturbance. Buysse et al. showed that this score gave a diagnostic sensitivity of 89.6% and specificity of 86.5% (kappa = 0.75, $P < 0.001$) in differentiating poor from good sleepers [38].

Weekend sleep delay was calculated by subtracting the weekday sleep time from the weekend sleep time for those who reported going to bed on the weekend the same time as the weekday or later. Weekend rise delay was calculated by subtracting the weekday rise time from the weekend rise time for those who reported waking up on the weekend the same time as the weekday or later. We excluded from these calculations day sleepers[1] (a definition of day and night sleepers is provided in the following paragraph).

Reversed sleep cycle was defined as an average sleep bedtime between 07:00 and 20:59 over the past month. For the purpose of reporting the results, students with the reversed sleep cycle were classified into the group called 'day sleepers', while those sleeping between 21:00 and 06:59 were called 'night sleepers'.

The ESS is a validated and reliable self-administered questionnaire used to assess subjective daytime sleepiness [39]. Although originally designed for adults, it has also been used for adolescents. The students were asked to rate the extent of daytime sleepiness in terms of the likelihood of dozing off or falling asleep in eight different situations or activities that are part of the daily routine of most people. A score between 0 and 24 is calculated as a sum of all eight items, and the score reflects the student's average sleep propensity, with higher scores indicating higher levels of daytime sleepiness. A student with a score of more than 10 was considered to have excessive daytime sleepiness.

The PSS is a psychological scale that is widely used to measure stress and the extent to which one's life events are considered stressful [40,41]. Higher values reflect higher levels of perceived stress. Students' feelings and thoughts about their lives (being unpredictable, uncontrollable, and over loaded) in the past month are evaluated through statements with responses graded on a 5-point scale (from 0 = never to 4 = very often). A cutoff point[2] for stress was considered to be 26 [40].

2.3. Questionnaire administration

The questionnaire was administered in Arabic. To ensure that the translation was as close in meaning to the original questionnaires and scales as possible, the forward-backward-forward technique was used. The questionnaire was first translated to Arabic by the Arabic speaking principal investigator and an Arabic language teacher (forward). Then, the questionnaire was given to a third party with no previous knowledge of the original questionnaire and that person translated the questionnaire back to English (backward). Conceptual equivalence was then compared and evaluated to generate the final Arabic version (forward). To our knowledge, at the time that we planned and conducted our study, there were no studies that validated the Arabic version of the questionnaires used. However, in general, questions that inquire about sleep over a recent period and request continuous responses have been shown to bear a strong correlation to objective measures [42]. Cronbach's alpha for reliability was calculated for PSQI (14 items; $\alpha = 0.72$), for PSS (10 items; $\alpha = 0.72$), and for ESS (8 items; $\alpha = 0.60$).

A pilot study was conducted on a convenient sample of 40 students to determine the average time required to fill the questionnaire and to discover any difficulties that the students might find with the vocabulary of the questionnaire. The average time to fill the questionnaire was 15 minutes, and the layout and vocabulary of one question was changed on the basis of the obtained results.

Ethical approval was obtained from the ethical committee at the Faculty of Medicine, King Abdulaziz University. Permission was granted from the Ministry of Education to administer the questionnaire in the selected schools. Questionnaires were distributed and collected by medical interns who attended a training session on the study objectives, the content of the questionnaire, and possible responses to questions. Questionnaires were presented to students as a school based survey inquiring about lifestyle and daily habits. They were told that participation was voluntary and reassured that all answers would be kept confidential, and were instructed to feel free to skip any questions should they feel uncomfortable answering them.

2.4. Data analysis

Bivariate analysis was used to determine the relationship between all risk factors and sleep outcomes. The association between demographic/lifestyle factors and sleep–wake patterns [school night bedtime, sleep latency (time to fall asleep), school night rise time, school night total sleep time, weekend bedtime, weekend rise time and weekend sleep delay] as well as sleep disturbance (measured by PSQI score) and EDS (measured by ESS score) was analyzed using independent *t*-tests and one-way analysis of variance (ANOVA). When significant effects were found using one-way ANOVA, it was followed up by Tukey post-hoc tests to determine significant intergroup mean differences. To calculate the prevalence of sleep disturbance, students with a PSQI score >5 were considered to have sleep disturbance and to calculate the prevalence of EDS, students with an ESS score >10 were considered to have excessive daytime sleepiness.

Stepwise linear regression was used to investigate all potential predictors of sleep–wake patterns (school night total sleep time, school night bedtime, sleep latency and weekend sleep delay), sleep disturbance and excessive daytime sleepiness. Potential predictors were demographic variables (sex, age, grade, school type and school district), and lifestyle variables (academic performance/GPA, napping, caffeine intake, hypnotic medication use, sleep cycle (day/night sleeper), and stress level). A backward selection algorithm was used and a *P* value of 0.1 was chosen as the significance level for removal of variables from the model and a *P* value of 0.05 was chosen as the significance level for entry of variables into the model. The significance level was set at 0.05. All statistical analysis was done using STATA version 13 (StataCorp, College Station, TX, USA).

3. Results

3.1. Characteristics of the study population

Students' characteristics are displayed in Table 1. The total number of students was 947, and females represented 55% of the sample. The sample age ranged between 14 and 23 years, with the majority of the sample (86%) aged between 16 and 18 years. Students were enrolled in private (47%) or governmental high schools (53%) representing the four districts of Jeddah city. They attended grade 10 (37%), grade 11 (34%), or grade 12 (29%). Over half the students reported excellent academic performance in the previous year, while 31% and 13% had good and good or below academic performance, respectively. With regard to their lifestyle, 89% of the students reported napping during the day, of which 59% reported occasional

[1] We excluded the day sleepers from the calculation of weekend sleep delay and weekend rise delay because of their extremely different sleep pattern from night sleepers and the lack of sufficient information to compare their sleep schedules during the week to their sleep schedules during the weekend.

[2] Scores are calculated and compared with a table with normal values. The smallest age group in the table is 18–29 years with a mean PSS score of 14.2 ± 6.2. Our study PSS scores of students below 18 years were compared with PSS scores of students 18 years and older, and the scores were comparable with no significant difference. Thus, for the whole student population, the cutoff point was determined by adding two standard deviations to the mean PSS score value 14.2.

Table 1
Demographic and lifestyle factors of the study population.

Variables	Frequency	%
Demographic factors		
Sex ($n = 947$)		
Male	424	45
Female	523	55
Age ($n = 939$)		
14–15	65	7
16	268	29
17	337	36
18	201	21
≥19	68	7
Grade ($n = 941$)		
10th	349	37
11th	323	34
12th	269	29
School type ($n = 946$)		
Private	448	47
Governmental	498	53
School district ($n = 947$)		
North	162	17
Middle	250	26
South East	273	29
South West	262	28
Academic and lifestyle factors		
Academic performance ($n = 922$)		
Excellent	522	57
Very good	283	31
Good or below	117	13
Napping ($n = 925$)		
No	101	11
Yes, sometimes	546	59
Yes, everyday	278	30
Caffeine intake per day ($n = 935$)		
No	252	27
1–2 cups	507	54
3–4 cups	124	13
5 or more cups	52	6
Hypnotic medication use ($n = 923$)		
Never	826	89
<1 time/week	52	6
1–2 times/week	32	3
≥3 times/week	13	1
Stress level ($n = 888$)		
Not stressed	707	80
Stressed	181	20

napping while 30% reported napping every day. The majority of students (73%) drank caffeinated beverages on a daily basis, with around 20% drinking three or more cups per day. Four percent of students reported using hypnotic medications at least once per week over the past month, and 6% reported using them less than once per week.

3.2. Sleep–wake schedules: patterns and predictors

Table 2 illustrates the sleep–wake patterns of students classified by age and sex. The average school night bedtime and wake time were 23:55 ± 03:21 and 06:51 ± 03:25, respectively. Around 32% reported sleeping after midnight, and around 30% reported waking up before 06:00. The average total hours of sleep each night was 7.0 ± 2.72. About 30% of the students reported sleeping 5 hours or less each night. Students required an average of 24 ± 24 minutes to fall asleep at night. Average weekend sleep and rise time were 02:23 ± 03:11 and 12:02 ± 03:25, respectively. Among night sleepers, 90% reported sleeping on weekends at the same time or later than school nights and among those students the mean delay was 2.8 ± 1.9 hours (median delay, 2.5 hours). Also among night sleepers, 96% reported that they woke up on weekends at the same time or later than on school days, and among those students the average delay in rise time was 6.0 ± 3.0 hours (median delay, 6 hours).

Table 2
Distribution of sleep–wake patterns among the total study population by age and sex.

Variable	Total ($n = 947$)	Age (years)						Sex		
		14–15	16	17	18	19–23	*P*-value	M	F	*P*-value
School night bedtime	23:55 (3:21)	23:39 (2:29)	23:41 (3:09)	0:00 (3:12)	0:03 (3:53)	23:55 (3:22)	0.529	0:00 (4:00)	23:51 (2:47)	0.522
Sleep latency (min)	24 (24)	16 (13)	25 (28)	24 (22)	25 (25)	28 (25)	0.043[a]	23 (23)	24 (25)	0.390
School night rise time	6:51 (3:25)	6:07 (1:54)	6:31 (3:06)	7:03 (3:29)	7:02 (3:46)	7:28 (4:20)	0.060	7:13 (3:40)	6:35 (3:11)	0.006
Total sleep time (h)	7.0 (2.7)	6.5 (2.2)	7.0 (2.7)	6.9 (2.7)	7.0 (2.9)	7.6 (2.8)	0.298	7.1 (2.8)	6.9 (2.7)	0.263
Weekend sleep time	2:23 (3:11)	1:30 (3:27)	2:05 (3:02)	2:35 (3:04)	2:41 (3:04)	2:54 (4:08)	0.019[b]	2:36 (3:38)	2:13 (2:49)	0.069
Weekend rise time	12:02 (3:25)	10:47 (3:12)	11:54 (3:07)	12:18 (3:36)	12:13 (3:24)	12:24 (3:49)	0.013[c]	12:21 (3:36)	11:48 (3:16)	0.007

Comparisons of sleep–wake patterns between age groups were based on one-way analysis of variance (Tukey's honest significant difference post-hoc test) and comparisons between males and females were based on *t*-tests. School night bedtime, school night rise time, weekend sleep time and weekend rise time are presented as mean (hour:minutes) (standard deviations); sleep latency is presented as mean (standard deviation) in minutes and total sleep time is presented as mean (standard deviation) in hours.

[a] 14–15 < 17, 14–15 < 18, 14–15 < 19–23.
[b] 14–15 < 18, 14–15 < 19–23.
[c] 14–15 < 17, 14–15 < 18, 14–15 < 19–23.

The bedtime and rise time, sleep latency, and total sleep time recorded for school days increased with age. However, the differences between ages were non-significant, except in the case of sleep latency ($P = 0.043$). Significant differences were found between age groups in weekend sleep time ($P = 0.019$) and weekend rise up time ($P = 0.013$). Post-hoc analysis revealed that on weekends, a delay in sleep and rise time occurred as age increased. With regard to gender, female subjects woke up significantly earlier than male subjects on school nights ($P = 0.006$) and later than males on weekends ($P = 0.007$).

Around 10% of the students reported having a reversed sleep cycle. A comparison between the sleep patterns of day sleepers and night sleepers is presented in Table 3. Day sleepers slept and woke up at significantly different hours than night sleepers. On average, day sleepers slept at 13:28 ± 03:21 and woke up at 21:01 ± 06:47, while night sleepers slept at 00:17 ± 01:38 and woke at 06:36 ± 02:43. Day sleepers reported significantly longer total sleep time ($P < 0.001$), later weekend bedtimes ($P < 0.001$), and earlier weekend rise times ($P = 0.006$) than night sleepers. Sex was the only significantly different demographic variable between day and night sleepers, with around 12% of boys and 7% of girls being day sleepers ($P = 0.019$). In regard to lifestyle and academic factors, a significant difference was found between the different grade point average (GPA) groups. The proportion of daytime sleepers decreased as GPA improved with around 7% of students with a GPA of excellent, around 9% of students with a GPA of very good and around 20% of students with a GPA of good or below being day sleepers ($P < 0.001$). No significant differences were found between day and night sleepers in the prevalence of sleep disturbance or EDS.

Table 3
Sleep–wake patterns, demographic and lifestyle variables of night and day sleepers.

Variable	Sleep cycle		*P*-value
	Night sleeper ($n = 823$)	Day sleeper ($n = 86$)	
Sleep–wake patterns, mean (SD)			
School night bedtime	0:17 (1:38)	13:28 (3:21)	<0.001
Sleep latency (min)	24 (24)	23 (24)	0.671
School night rise time	6:36 (2:43)	21:01 (6:47)	<0.001
Total sleep time (h)	6.8 (2.6)	8.5 (3.3)	<0.001
Weekend sleep time	2:30 (2:55)	5:11 (5:47)	<0.001
Weekend rise time	12:06 (3:09)	11:02 (4:57)	0.006
Demographic and lifestyle factors, *N* (%)			
Sex			
Male	351 (88)	48 (12)	0.019
Female	472 (93)	38 (7)	
Age (years)			
≤15	62 (95)	3 (5)	0.203
16	232 (90)	24 (10)	
17	296 (91)	26 (9)	
18	170 (87)	24 (13)	
≥19	55 (85)	9 (15)	
School type			
Governmental	429 (90)	50 (10)	0.293
Private	393 (92)	36 (8)	
Grade point average			
Excellent	469 (93)	38 (7)	<0.001
Very good	243 (91)	25 (9)	
Good or below	87 (80)	22 (20)	
Stress level			
High	616 (90)	68 (10)	0.66
Normal	155 (91)	15 (9)	
Caffeine intake/day			
No	227 (92)	19 (8)	0.307
1–2 cups	438 (90)	48 (10)	
3–4 cups	106 (91)	11 (9)	
≥5 cups	41 (84)	8 (16)	
Hypnotic medication use			
Never	716 (90)	77 (10)	0.497
<1/week	48 (92)	4 (8)	
1–2 times/week	30 (97)	1 (3)	
≥3 times/week	10 (83)	2 (17)	

Comparisons of sleep–wake patterns between day and night sleepers were based on *t*-tests, and comparisons of demographic and lifestyle factors between day and night sleepers were based on χ^2-tests. School night bedtime, school night rise time, weekend sleep time and weekend rise time are presented as mean (hour:minutes) (standard deviation); sleep latency is presented as mean (standard deviation) in minutes and total sleep time is presented as mean (standard deviation) in hours.

Table 4 shows the association between demographic and lifestyle factors and sleep–wake patterns, including school night bedtime, total sleep time, weekend sleep delay and sleep latency. The final linear regression model for sleep–wake patterns included several significant predictors (Table 5). Students who took more naps, used hypnotic medication more frequently, and consumed more caffeine were more likely to have later school night sleep times than others. Students with reversed sleep cycles and lower GPA were more likely to have longer total sleep times than their counterparts. Male students and students with lower GPA were more likely to have weekend sleep delay than other students. Older students, students with higher GPA, students who took more naps and used hypnotic medication more frequently were more likely to have longer sleep latencies.

3.3. *Sleep disturbance and excessive daytime sleepiness: prevalence and predictors*

Around 65% of the students were found to have a PSQI global score of >5, which reflects disturbed sleep. Disturbed sleep was significantly higher in girls than boys ($P = 0.004$). EDS was reported by 37% of the students. Table 6 shows the association between demographic and lifestyle factors with sleep disturbance and excessive daytime sleepiness. Factors with the highest statistical significance are sex ($P < 0.001$), napping ($P < 0.001$), and stress level ($P < 0.001$). The final linear regression model for disturbed sleep and EDS included several significant predictors (Table 5). Female students were more likely to have higher PSQI scores. On the other hand, students who were enrolled in private schools were stressed, took naps, and consumed more caffeine were more likely to have higher ESS scores.

4. Discussion

This study investigated the sleep–wake patterns, sleep quality and daytime sleepiness among adolescents in Saudi Arabia and the factors associated with these outcomes. Our main findings were that students were sleep deprived and had a high prevalence of sleep disturbances (65%). Our findings also showed, for the first time, a reversed sleep cycle among 10% of high school students, indicating that students stayed up all night and slept after returning from school.

This study found that on average, students were getting 7.0 hours of sleep each night, and around 30% of the students slept 5 hours or less each night. Studies on Saudi secondary school students have reported similar mean total sleep times (7.1 and 7.2 hours) [36,37] and 30% of the students slept less than 7 hours each night. This total sleep time is slightly lower than that reported in other countries: adolescents in Iran (7.7 hours) [28], Israel (7.3 hours) [10], Hong Kong (7.3 hours) [1], and South Africa (7.3 hours) [43] were reported to sleep for a longer time. However, the total sleep time recorded in this study is longer than that reported in Greece (6.9 hours) [44]. The duration of 7.0 hours indicates that adolescents were getting sleep for lesser hours than required.

On average, students slept on weekdays at around 23:55 and woke up at 06:51. High schools in Saudi Arabia start at around 07:00 and no later than 07:30 each morning, which mandates adolescents to wake up at an early hour. A study by Epstein et al. revealed that students (age, 10–12 years) who started school at 07:15 or

Table 4
Association between demographic and lifestyle factors and sleep–wake patterns (school night bedtime, total sleep time, sleep latency and weekend sleep delay).

Variable	School night bedtime		Total sleep time		Weekend sleep delay[a]		Sleep latency	
	Mean (SD)	*P*-value	Mean (SD)	*P*-value	Mean (SD)	*P*-value	Mean (SD)	*P*-value
Sex								
Male	00:00 (4:00)	0.573	7.1 (2.8)	0.217	3.1 (2.0)	<0.001	23 (23)	0.387
Female	23:54 (2:48)		6.9 (2.7)		2.6 (1.8)		25 (26)	
Age (years)								
14–15	23:42 (2:30)	0.529	6.5 (2.2)	0.298	2.6 (2.1)	0.546	13 (60)	0.042[b]
16	23:47 (3:12)		7.0 (2.7)		2.9 (1.9)		25 (28)	
17	00:00 (3:12)		6.9 (2.7)		2.9 (2.0)		24 (22)	
18	00:06 (3:54)		7.0 (2.9)		2.7 (1.7)		25 (25)	
19–23	00:24 (4:24)		7.6 (2.8)		3.0 (2.1)		28 (25)	
School type								
Governmental	23:54 (3:36)	0.943	6.9 (2.8)	0.747	2.9 (2.0)	0.150	24 (24)	0.460
Private	23:54 (3:06)		7.0 (2.6)		2.7 (1.8)		25 (24)	
Grade point average								
Excellent	23:48 (3:00)	0.253	6.7 (2.5)	0.005[c]	2.6 (1.8)	<0.001[d]	25 (26)	0.442
Very good	00:12 (3:24)		7.2 (2.8)		3.2 (2.0)		25 (24)	
Good or below	23:54 (4:48)		7.5 (3.4)		3.1 (2.2)		22 (20)	
Napping								
No	22:48 (3:36)	<0.001[e]	6.9 (2.0)	0.184	2.4 (1.6)	0.003[f]	24 (24)	0.030[g]
Yes, sometimes	23:48 (3:18)		7.1 (2.8)		3.0 (2.0)		24 (25)	
Yes, everyday	00:24 (3:18)		6.7 (2.8)		2.6 (1.8)		27 (26)	
Stress level								
High	00:06 (3:18)	0.396	6.9 (3.1)	0.613	2.8 (1.9)	0.687	27 (27)	0.126
Normal	23:54 (3:24)		7.0 (2.6)		2.9 (2.1)		23 (24)	
Caffeine intake/day								
No	23:36 (3:12)	0.111	6.9 (2.7)	0.716	2.5 (1.9)	0.028[‡‡]	25 (26)	0.456
1–2 cups	23:54 (3:24)		6.9 (2.6)		2.9 (1.9)		23 (22)	
3–4 cups	00:24 (3:30)		7.1 (3.1)		3.0 (2.0)		27 (31)	
≥5	00:30 (4:00)		7.4 (3.3)		3.1 (2.0)		25 (23)	
Sleep cycle								
Night sleeper	–	–	6.8 (2.6)	<0.001	–	–	24 (24)	0.671
Day sleeper	–		8.5 (3.3)		–		23 (24)	
Hypnotic medication use								
Never	23:48 (3:18)	0.135	6.9 (2.7)	0.869	2.8 (1.9)	0.897	24 (24)	0.003[h]
<1/week	00:06 (3:18)		7.2 (3.0)		3.0 (2.1)		26 (28)	
1–2 times/week	01:00 (2:12)		7.0 (2.3)		2.9 (1.5)		30 (21)	
≥3 times/week	01:12 (4:54)		6.7 (3.9)		2.4 (2.0)		48 (52)	
Total	23:54 (3:24)		7.0 (2.7)		2.8 (1.9)		24 (25)	

Comparisons of sleep–wake patterns were based on one-way analysis of variance (Tukey's honest significant difference post-hoc test) and *t*-tests. School night bedtime is presented as mean (hour:minutes) (standard deviation); total sleep time and weekend sleep delay are presented as mean (standard deviation) in hours; sleep latency is presented as mean (standard deviation) in minutes.

[‡‡] No < 5 or more cups.

[a] Weekend sleep delay was calculated for night sleepers only (excluding day sleepers).

[b] 14–15 < 16, 14–15 < 18, 14–15 < 19–23.

[c] Excellent < Good or below.

[d] Excellent < Good or below; Excellent < Very good.

[e] No < Yes, sometimes; and No < Yes, every day.

[f] No < Yes, sometimes.

[g] No < Yes, every day.

[h] Never < 3 or more times/week; Less than 1/week < 3 or more times/week; 1 or 2 times/week < 3 or more times/week.

earlier slept significantly less than those who started late (08:00 or later) [45]. Although not significantly different, a delay in school night bedtime was observed with an increase in age, which is in keeping with the findings reported worldwide [5]. Although girls and boys went to bed at around the same time on school days; at 23:51 and 00:00, respectively, girls on average woke up earlier than boys, at 06:35 vs. 07:13, respectively. This was comparable with the findings obtained for female students in Germany who also showed earlier rise times than boys [2]. Girls could be waking up earlier in our study sample because females in Saudi Arabia cannot drive and in most cases do not have effective public transportation to get them to school. Thus, they are either dropped off by a male chaperon or take the school bus, both of which would force them to wake up earlier than boys who drive to school themselves. One-third of the students slept after midnight, which reflects poor sleep habits among students. In order to obtain a sleep duration of 8–9 hours, students must go to bed at an earlier hour, at around 22:00 [25]. Our study found that factors associated with later school night sleep times include taking more naps, using hypnotic medication, and consuming more caffeine. Similarly, a study on adolescents' sleep behavior in South Africa revealed that later bedtime was significantly associated with napping and caffeine consumption [43].

Poor sleep quality, in terms of a global PSQI of >5, was found in two-thirds of our students, which is higher than the reported prevalence in other countries. Around 40% of Japanese adolescents identified their sleep as being "poor or very poor", and 8% of Iranian adolescents identified their sleep quality as being "bad" [24,28]. Disturbed sleep was significantly more frequent among girls than boys. Similarly, in Hong Kong, adolescent girls had significantly higher PSQI scores than boys [1], and in Japan, significantly more girls rated their sleep as being "poor or very poor" compared with boys [24].

An interesting finding in our study was that 1 in 10 of the students reported a reversed sleep schedule (day sleepers). These students slept after the end of the school day on average at 13:28 (most governmental schools end at 13:30) and woke up on average at 21:02. Day sleepers slept significantly longer than night sleepers on weekdays (8.5 and 6.8 hours), respectively. Although day and night sleepers shared similar sleep latency times of 23 and 24 min, respectively, we suspect

Table 5
Final linear regression models of predictors of sleep–wake patterns, sleep disturbance, and excessive daytime sleepiness.

Predictors	Coefficient	SE	*P*-value
School night bedtime (h)			
Napping	0.72	0.19	<0.001
Hypnotic medication use	0.41	0.21	0.058
Caffeine	0.27	0.15	0.079
Total sleep time (h)			
Day sleeper	1.69	0.33	<0.001
GPA	−0.33	0.14	0.016
Weekend sleep delay (h)[a]			
Sex (female = 1)	−0.33	0.16	0.043
GPA	−0.24	0.12	0.041
Sleep latency (min)			
Hypnotic medication use	5.12	1.57	0.001
Napping	3.75	1.43	0.009
GPA	2.57	1.31	0.049
Age	2.21	0.90	0.014
PSQI score			
Sex (female = 1)	0.83	0.25	0.001
ESS score			
Stress level (stressed = 1)	1.50	0.35	<0.001
Napping	1.50	0.22	<0.001
School type (private = 1)	0.73	0.28	0.008
Caffeine	0.37	0.18	0.039

Abbreviations: SE, standard error; GPA, grade point average; PSQI, Pittsburgh Sleep Quality Index; ESS, Epworth Sleepiness Scale.
Linear stepwise regression results are presented as β coefficients and standard deviation in minutes for sleep latency and in hours for school night bedtime, total sleep time and weekend sleep delay.
[a] Weekend sleep delay was calculated for night sleepers only (excluding day sleepers).

differences in wake after sleep onset may be present. This needs to be investigated in future studies. In regards to demographic and lifestyle differences, we found a higher prevalence of day sleepers among males, and an increase in prevalence of day sleepers with the increase in GPA. A recent study by Lovato et al. assessed whether adolescents with and without delayed sleep phase disorder (DSPD) showed similar trends in weekend delay times and in levels of daytime sleepiness [46]. Similar to our results, students with DSPD slept later during the weekends than students without DSPD, and they exhibited a similar level of daytime sleepiness. Moreover, sleep hygiene practices were similar between both groups. However, their results did not show the gender or grade differences that were seen in our study. It is important to note that these students with DSPD did not exhibit a delay as extreme as day sleepers in our study. For future surveys on adolescent's sleep habits, we highly recommend adding a question that explicitly inquires about the presence and frequency of a reversed sleep cycle, perhaps over the past 12 months, and adding more questions about lifestyle and demographic factors that may be associated with such a sleep schedule (e.g. working hours, electronic media use at night, parental educational level). Objective measures like actigraphy can give even more accurate results.

Weekend bedtime and rise time differed drastically from school night bedtime and rise time in our study population. On average, night sleepers slept at 02:30 and woke up at 12:06 on weekends, with a weekend bedtime delay of 2.8 hours and rise delay of 6 hours, which is a much greater delay than that reported internationally [47]. The sleep patterns of adolescents all over the world showed a consistent average delay in weekend bedtime of 2 hours and rise time of 2 hours and 30 minutes [5]. In addition, male students and students with lower GPAs were more likely to have a longer weekend bedtime sleep delay. A study from Hong Kong also found that having a weekend sleep delay of over 2 hours was associated with poor academic performance [48]. Day sleepers seemed to reverse their sleep schedule back during the weekend, with an average bedtime at 05:11 and rise time at 11:02. We, however, did not have sufficient information to understand whether (and for how long) these students were sleeping during the day over the weekend, and the standard deviations were large, pointing to a need for more detailed questions.

Napping, which was reported by the majority of students in this study, is a well known habit in Asia [3,49] and in some European countries [44]. In India, Greece, and Brazil napping is a prevalent cultural habit. Most commercial stores and businesses close between 13:30 and 17:00 in Saudi Arabia. This reduces the scope for activity – an optimal chance to take a nap. In a local study on elementary school children, almost half reported napping on weekdays, for an average of 1.6 hours [33].

Daytime sleepiness was found in more than a third (37%) of the students, with the ESS score being greater than 10. EDS detected by the ESS varied in reports from different countries to range from 24% in China [50] to 83.4% in Iceland. Percentages similar to that seen in our study were reported in the US (37%) [26] and Hong Kong (41.9%) [1]. Although sex was significantly associated with EDS in the bivariate analysis, it was not a significant predictor in the final regression model. Higher prevalence of daytime sleepiness among girls in comparison with boys was reported in countries like Japan and Hong Kong [1,24].

We further found that students with lower GPAs slept longer hours each night compared with those with higher GPAs. This contradicts the findings of previous studies that show that students who sleep less usually present with lower grades than their peers who are better sleepers [1,18]. A meta-analysis by Dewald et al. on the influence of sleep quality, sleep duration, and sleepiness on school performance concluded that all three sleep variables were significantly but modestly related to school performance [6]. However, Xu et al. reported that students with higher grades were more likely to have disturbed sleep and further explained that this may be due to the academic stresses that students face, especially in their final year, in order to get into good universities [50], which we think may apply to our study population too.

The implications of identifying the factors associated with poor sleep in our study population can be viewed as relevant to healthcare workers interacting with adolescents, as well as policy makers in the educational field. Healthcare workers including physicians, school nurses and counselors should adopt a low threshold for suspecting sleep problems among high school students. Since our findings identified that female students were at higher risk of disturbed sleep, and male students were at higher risk of having a reversed sleep cycle and weekend sleep delays, gender-specific advice may be appropriate for this age group.

Our findings can also inform policy makers interested in planning and implementing sleep hygiene educational programs. Napping, hypnotic medication use and caffeine intake, all of which are predictors of delayed school night bedtime in our study, and excessive daytime sleepiness (predicted by napping and caffeine intake only), are modifiable habits that can be addressed through educational programs. Stress level, which can also be modified, was predictive of excessive daytime sleepiness. A basic 2-hour educational intervention for students aged 17–19 years that addressed sleep need, sleepiness, and sleep problems was tested in Italy and showed low baseline knowledge that increased significantly among the group receiving the intervention compared with those who haven't, both directly post-intervention and 3 months later [51]. A similar program can be adopted in Saudi schools to incorporate information on proper sleep hygiene.

Findings from our study show a general trend of insufficient sleep among adolescents, but higher GPA was also predictive of shorter total hours of sleep each night. Delaying school start times can significantly improve adolescents' total sleep hours. Studies comparing early and late school start times have consistently shown that adolescents who start school later sleep longer than their peers who start school at an early hour [8,9,52]. Even a small delay of 30

Table 6
Association between demographic and lifestyle factors and sleep disturbance and excessive daytime sleepiness.

Variable	PSQI (sleep disturbance)		ESS (excessive daytime sleepiness)	
	Mean (SD)	*P*-value	Mean (SD)	*P*-value
Sex				
Male	6.3 (3.0)	0.001	8.8 (4.0)	<0.001
Female	7.1 (3.1)		9.7 (4.0)	
Age (years)				
≤15	7.3 (3.0)	0.414	8.9 (4.3)	0.508
16	6.7 (3.2)		9.3 (3.8)	
17	6.6 (3.1)		9.6 (3.9)	
18	7.1 (2.9)		9.3 (4.1)	
≥19	6.5 (2.9)		8.8 (4.3)	
School type				
Governmental	6.7 (3.0)	0.406	9.0 (3.9)	0.023
Private	6.9 (3.2)		9.6 (4.0)	
Grade point average				
Excellent	6.2 (2.9)	0.029[a]	9.6 (3.9)	0.062
Very good	6.6 (3.0)		8.9 (4.0)	
Good or below	6.1 (2.9)		9.1 (4.3)	
Napping				
No	6.6 (3.0)	0.752	7.7 (3.7)	<0.001[b]
Yes, sometimes	6.8 (3.2)		9.0 (3.7)	
Yes, every day	6.8 (3.1)		10.5 (4.2)	
Stress level				
High	6.8 (3.2)	0.873	10.9 (4.0)	<0.001
Normal	6.8 (3.1)		8.9 (3.9)	
Caffeine intake/day				
No	6.7 (3.2)	0.818	9.0 (3.8)	0.047[c]
1–2 cups	6.9 (3.1)		9.3 (4.0)	
3–4 cups	6.8 (3.1)		9.6 (3.8)	
≥5 cups	7.3 (3.3)		10.7 (4.9)	
Sleep cycle				
Night sleeper	6.8 (3.1)	0.293	9.3 (3.9)	0.504
Day sleeper	7.2 (3.0)		9.0 (4.3)	
Hypnotic medication use				
Never	6.8 (3.1)	0.433	9.3 (4.0)	0.281
<1/week	6.3 (2.4)		10.0 (3.6)	
1–2 times/week	7.6 (3.0)		8.9 (3.4)	
≥3 times/week	7.2 (4.7)		10.8 (5.2)	
Total	6.8 (3.1)		9.3 (4.0)	

Abbreviations: PSQI, Pittsburgh Sleep Quality Index; ESS, Epworth Sleepiness Scale.
Comparisons of sleep–wake patterns were based on one-way analysis of variance (Tukey's honest significant difference post-hoc test) and *t*-tests.
[a] Excellent > Good or below.
[b] No < Yes, sometimes; No < Yes, every day; Yes, sometimes < Yes, every day.
[c] No < 5 or more; 1–2 cups < 5 or more.

minutes in school start time (from 08:00 to 08:30) showed a 45 minute increase in mean sleep duration in a US study, with the percentage of students getting at least 8 hours of sleep increasing from 16.4% to 54.7% [53]. Interestingly, studies have also shown that students who started school later did not seem to go to bed later than their counterparts who started school early [8,52].

There are a few limitations to our study. First, because our results are based on cross-sectional data, the temporal relationship between the predictors and outcomes is not clear, and no causal inferences can be made. Second, the self-reported nature of data collection may have introduced reporting bias in the form of recall bias or response bias and demand characteristics. Evidence has shown that self-reports of health-risk behaviors in adolescents could be affected by cognitive and situational factors [54]. A multimeasure approach by using laboratory or actigraphy reporting in addition to self-reports may have given more reliable assessments. Finally, to our knowledge, at the time of conducting this study, there were no validated Arabic versions of the PSQI, PSS, or ESS.

Our study fills a gap in the information regarding adolescents' sleep behavior in the Middle Eastern region and sheds light for the first time on some distinct aspects of adolescents' sleep habits in Saudi Arabia. Although adolescents in Saudi Arabia seem to be similar to their counterparts worldwide in terms of getting insufficient average hours of sleep and showing a high prevalence of daytime sleepiness, they showed a higher percentage of poor sleep quality and a greater delay in weekend sleep and rise time. Planning sleep hygiene educational programs targeting parents, teachers, as well as adolescents is recommended. Education policy makers may consider delaying school start time as a remedial measure. Furthermore, an alarming pattern of reversed sleep was present, highlighting the need for further investigation in future studies.

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Conflict of interest

There are no conflicts of interest to be disclosed for this study.

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